METHOD OF MAKING METAL CONTAINERS

[0001] This application claims priority of provisional Application Serial No. 60/418,621 filed on October 15, 2002.

FIELD OF THE INVENTION

[0002] The present invention relates to a method and apparatus for forming lightweight impact extruded metal containers.

BACKGROUND OF THE INVENTION

[0003] Metal containers, such as aluminum beverage and aerosol containers, are typically formed by impact extrusion or by cupper/bodymaker methods. Impact extruded metal containers are formed by plastic deformation of a disk-shaped metal slug into a cylindrical container having approximately the same height, diameter, base thickness and wall thickness as the finished container. The metal slug is placed at the bottom of a cylindrical die and struck with a high-speed cylindrical punch. The impact causes the metal slug to flow backward along the punch to form the extruded cylindrical container.

[0004] The extruded container is wall ironed to the diameter and wall thickness of the finished container, by placing the container over a cylindrical ironing punch and passing the container through a ring of narrowing diameter. The reduction in diameter and thickness of the

wall causes the container to increase in length. The wall ironed container is then trimmed to the appropriate height.

[0005] The trimmed, wall ironed container may then receive interior and exterior coatings, such as primers, lithography and lacquer. The top of the container may also be shaped to form a neck, by insertion into a series of neck forming dies, and then threaded, curled or otherwise shaped to receive a screw cap, aerosol nozzle or other closure. Further shaping operations may be applied to the body of the container, to form a grip or other design.

[0006] Because of the amount of work required to plastically deform the metal slug, it has been necessary to manufacture the containers using relatively soft metal alloys, such as 1000 series aluminum which has less than or equal to 1% impurities. The use of such soft aluminum alloys requires the container to be designed with a relatively thick wall and base, to provide sufficient strength when the containers are stacked or when the contents are pressurized. High strength alloys, such as 3000 series aluminum alloys, would permit the manufacture of relatively lightweight containers with significantly thinner walls and base, while providing sufficient strength to withstand the weight of stacked containers or internal pressurization. However, such high-strength alloys are difficult to form by impact extrusion, and cause excessive wear and replacement of extrusion tooling. Thus, it has not been economically feasible to produce metal containers using high-strength alloys by impact extrusion.

[0007] Thin-walled containers made of high-strength alloys are typically produced from coiled metal sheet stock using the cupper/bodymaker method. The thickness of the metal sheet is preselected to be the same as the base thickness of the finished container, thus avoiding the severe deformation of the metal required to form the container by the impact extrusion process. The metal coil is unwound and fed into a cupper, which stamps a round blank from the sheet.

The blank is then pressed into a die to form a cup-shaped cylindrical container, that has a substantially larger diameter and is correspondingly shorter than the finished container. Because the metal is not plastically deformed, the base thickness and wall thickness of the cup retains the thickness of the metal sheet stock.

[0008] The cup is transferred to a bodymaker, which performs a series of wall ironing operations to sequentially reduce the diameter and wall thickness, and increase the height of the container to its appropriate height, diameter and wall thickness. The wall ironed container is then trimmed, necked and finished as described above for impact extruded containers.

[0009] There are several drawbacks to using the cupper/bodymaker method in comparison to impact extrusion methods. In particular, additional space and equipment is required for storage and handling of the large, heavy metal coils used to produce the containers. Furthermore, the cupper/bodymaker equipment is specifically designed to produce containers having a particular diameter and height, and cannot efficiently be adapted to produce alternate size containers. Thus, each size container typically requires a separate cupper/bodymaker and production line.

[0010] In contrast, the metal slugs used in the impact extrusion method do not require special handling or storage and the extrusion equipment is readily adapted to produce different sized containers by simply changing the size of the metal slug, and/or the size of the extrusion die and punch. Furthermore, the thickness of the base of the container can be changed by controlling the force of the extrusion punch, whereas the cupper/bodymaker method is limited to producing containers having the same base thickness as the thickness of the metal sheet stock.

[0011] In addition, the cupper/bodymaker method uses materials less efficiently than the impact extrusion method. Once the blanks are stamped from the metal sheet stock by the cupper,

the exhausted metal sheet must be recycled or scrapped. Thus, a significant portion of the material cost is not incorporated into the containers. Such costs are avoided by the impact extrusion method, which uses preformed metal slugs as the starting material. Furthermore, metal slugs are available in a broad range of sizes and alloys, and can be purchased in relatively small numbers from a wide range of suppliers, which allows production to be flexibly switched between small lots of different types of containers. In contrast, the metal coils used in the cupper/bodymaker method are only available in bulk quantities from a few suppliers, which restricts production to relatively large numbers of a single type of container.

[0012] Thus, there is a need for a method of producing metal containers that permits the use of high-strength metal alloys and that can readily be adapted to produce containers of different height and diameter.

SUMMARY OF THE INVENTION

[0013] These needs and other needs are satisfied by the present invention, which comprises a method of making lightweight containers from high-strength metal alloys. According to the inventive method, a metal slug formed of a high-strength alloy is impact extruded to form a cup-shaped container that has a substantially larger diameter and which is correspondingly shorter than the finished container. The extruded cup is then drawn to approximately the diameter of the finished container and the drawn container is wall ironed in one or more steps to reduce the diameter and wall thickness and increase the height of the container to the diameter, wall thickness and height of the finished container. The wall ironed container is then bottom formed and trimmed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIGURE 1 is a vertical section view of the extruded cup-shaped container of the present invention.

[0015] FIGURE 2a is a vertical section view of the disk-shaped metal slug of the present invention.

[0016] FIGURE 2b is a vertical section view of a disk-shaped metal slug having a domed shape.

[0017] FIGURE 3 is a vertical section view of the extrusion die and extrusion punch of the present invention.

[0018] FIGURE 4a is a detail section view of the corner of a prior art cylindrical extruded container.

[0019] FIGURE 4b is a detail section view of the corner of an embodiment of the extruded cup of the present invention.

[0020] FIGURE 4c is a detail section view of the corner of the extruded cup of Fig. 2.

[0021] FIGURE 5 is a vertical section view of the drawn cup of the present invention.

[0022] FIGURE 6 is a detail section view showing the first transitional wall thickness adjacent the base of the drawn cup of Fig. 5.

[0023] FIGURE 7 is a vertical section view of the partially wall ironed, extruded container of the present invention.

[0024] FIGURE 8 is a vertical section view of the fully wall ironed, extruded container of the present invention.

[0025] FIGURE 9 is a detail section view of the second transitional wall thickness defining the top and bottom wall of the fully wall ironed, extruded container of Fig. 8.

[0026] FIGURE 10 is a vertical section view of the fully wall ironed, domed container of the present invention.

DETAILED DESCRIPTION OF INVENTION

[0027] In accordance with the present invention, a method of making thin-walled lightweight metal containers is described, comprising impact extruding a disk-shaped slug to form a cup-shaped cylindrical container that has a substantially larger diameter and shorter height than the finished container. The extruded cup is drawn to reduce the diameter and wall ironed to increase the height of the container to the approximate diameter and height of the finished container. Thus, much of the work performed by prior art impact extrusion processes is transferred to the drawing and wall ironing operations, which require less severe deformation of the container. The wall ironed container is then domed, trimmed and necked to produce the finished container.

[0028] The extrusion of a cup having a larger diameter and shorter height significantly reduces the amount of metal working that must be performed by the impact extrusion process in contrast to conventional methods of extrusion. In addition, the increase in diameter allows for a corresponding reduction in the thickness of the slug, which further reduces the work required by the impact extrusion process in comparison to the prior art. As a result, the present invention allows the impact extrusion of high-strength alloys with less stress to the extrusion tooling. The use of such high-strength alloys permits the design of lightweight containers having thinner walls, while maintaining or increasing the strength of the container.

[0029] Figure 1 shows a cylindrical extruded cup **10** of the present invention, with a base **12** and walls **14**. The dimensions of extruded cup **10** are determined as a function of the size of the finished container. In general, extruded cup **10** is designed to have an outer diameter **A** that

is at least about 10% larger than the outer diameter of the finished container and preferably about 15% to about 25% larger than the outer diameter of finished container. The thickness **B** of base **12** of cup **10** preferably ranges from approximately 0.40 mm to 0.80 mm. Similarly, the thickness **C** of walls **14** of cup **10** preferably ranges from approximately 0.20 mm to 0.60 mm. The height **D** of cup **10** is dependent on the size of the extruded metal slug **16** (Fig. 2a) and may be calculated as a function of the cup diameter **A**, base thickness **B** and wall thickness **C**, in addition to other variables discussed herein. It will be understood by those of skill in the art that the dimensions of the extruded cup will vary in response to the size and type of metal alloy used to form the finished container.

[0030] In a most preferred embodiment, extruded cup **10** has an outer diameter **A** that is approximately 18% larger than the finished container, a base thickness **B** of approximately 0.60 mm, a wall thickness **C** of approximately 0.40 mm, and a resulting height that is roughly ½ the length of the finished container. However, it will be apparent to those of ordinary skill in the art that the preferred design of cup **10** will vary according to the size and function of the finished container.

[0031] Cup **10** is extruded from a disk-shaped metal slug **16**, as shown in Fig. 2a. The mass of slug **16** is calculated or empirically determined to form a container of sufficient length to allow approximately 10-20 mm to be trimmed from the top of the wall ironed, domed container, as described below. In general, slug **16** has a diameter **E** that is slightly smaller than outer diameter **A** of cup **10** and has a thickness **F** that ranges from approximately 2.0-4.0 mm. In contrast, conventional slugs are typically 50-100% thicker than the slugs used in the present invention. In a preferred embodiment, slug **16** has a diameter **E** that is approximately 0.350 mm smaller than diameter **A** of the cup **10**, and a thickness **F** that is approximately 2.50 mm. It will

be apparent to those of skill in the art that the mass and dimensions of slug **16**, are interrelated with outer diameter **A** of cup **10**, and must be taken into account when designing the configuration of cup **10**.

[0032] Slug **16** is preferably formed from high-strength alloys such 3000 series aluminum alloys -- e.g. 3002, 3102, 3003, 3103, 3203, 3004, 3104, 3204, 3005, 3105, 3006, 3007, 3107, 3307, 3009, 3010, 3011, 3012, 3013, 3014, 3015, 3016, 3017, 3019, 3020, 3025 and 3030, among others. Other materials may also be used, such as 6000 series aluminum alloys, steel and other metal alloys that are conventionally difficult to extrude. Those of skill on the art will appreciate that the present invention may also be adapted to use conventional materials, such as 1000 series aluminum alloys -- e.g. 1050, 1060, 1070 and 1100.

[0033] Figure 3 shows an extrusion die **18** and extrusion punch **20** for impact extrusion of cup **10**. Extrusion die and punch **18, 20** are adapted for use in conventional extrusion systems. Extrusion die **18** has a cylindrical interior wall **22** and a bottom surface **24**. Interior wall **22** of extrusion die **18** has a diameter that is equivalent to outer diameter **A** of cup **10**. Bottom surface **24** of extrusion die **18** comprises a flat, circular central portion **26** with a conical outer ring **28**. The angle of conical outer ring **28** ranges from approximately 1° to 15° relative to central portion **26**.

[0034] Extrusion punch **20** has a cylindrical outer surface **30** and a face **32**, which have a complementary configuration to interior wall **22** and bottom surface **24** of die **18**. The diameter of outer surface **30** is smaller than the diameter of interior wall **22**, by twice the wall thickness **C** of extruded cup **10**. The configuration of face **32** mirrors the configuration of bottom surface **24** of extrusion die **18**. The transition **34** between outer surface **30** and face **32** is a curve with a

radius of approximately 3.0-8.0 mm. Die **18** has a complementary transition curve **36** between interior wall **22** and bottom surface **24**.

[0035] As. shown in Figs. 1 and 4c, cup **10** has a base **12** shaped like an inverted, truncated cone, formed by cooperation of extrusion die and punch **18, 20**. Conical base **12** has a flat, circular central portion **38** with a conical outer ring **40** that respectively correspond to circular central portion **26** and conical outer ring **28** of extrusion die **18**. The corner **42** at base **12** of cup **10** is a curve with an interior radius **G** determined by the radius of transition **34** of extrusion punch **20**. The conical shape of base **12** further decreases the amount of work required during impact extrusion by increasing the angle of corner **42** between base **12** and wall **14**. In contrast, prior art containers are designed with a flat base which forces the extruded metal to flow through a relatively sharp angle, as shown in Figs. 4a.

[0036] In a preferred embodiment, extrusion die and punch **18, 20** are designed to produce a cup **10** with a conical base **12**, having an angle **H** of approximately 1° and an inner radius **G** of approximately 6.600 mm. However, it will be apparent to those of ordinary skill in the art that the preferred angle **H** and radius **G** will vary according to the size of the finished container.

[0037] In the alternative embodiment shown in Fig. 4b, base **12** is flat and cup **10** has a uniform base thickness and wall thickness. This simplified configuration eliminates the need to manage the transition between the different wall thickness and base thickness of the container as described below.

[0038] Further steps may be taken to facilitate the impact extrusion process. In an alternative embodiment, the slug **16** is coated with a lubricant and/or preheated prior to impact extrusion. In yet another embodiment, slug **16** may be provided in a shape that is more

conducive to forming, such as a domed shape shown in Fig. 2b which has a configuration similar to the conical configuration of extrusion die and punch **18, 20**.

[0039] Cup **10** is subjected to a series of drawing and wall ironing operations to reduced the diameter and wall thickness, and increase the height of the extruded container to approximately the diameter, wall thickness and height of the finished container. As shown in Fig. 5, cup **10** is drawn through one or more dies (not shown) to reduce the diameter of the extruded container to a diameter **I**, that is approximately the diameter of the finished container. The drawing die and punch (not shown) are designed to maintain the extruded wall thickness **C**, throughout the drawing operation. The reduction in diameter causes the container to lengthen to a height **J**. Such drawing operations are well known in the art and may be performed using commercially available equipment.

[0040] The drawing punch is provided with a conical portion adjacent the face, to form a taper **K** in the wall thickness at the base of the drawn container **44**, as shown in Figs. 5 and 6. As best seen in Fig. 6, conical taper **K** has an angle of approximately 0.5° and creates a transition between base thickness **B** and extruded wall thickness **C**. The length of conical taper **K** will vary according to the difference between base thickness **B** and extruded wall thickness **C**.

[0041] Drawn container **44** is subsequently inserted into a first bottom forming die with a flat bottom (not shown), which cooperates with the flat face of the drawing punch to remove the conical shape of base **12**. In addition, the bottom forming die and drawing punch are also designed to reduce the radius of corner **46** of drawn container **44** to the corner radius of the finished container. In a preferred embodiment, drawn container **44** is reduced to an outside diameter **I** that is less than approximately 1.0 mm larger than the diameter of the finished container.

[0042] The outer diameter **I** of drawn container **44** is reduced to the diameter of the finished container through a series of wall ironing operations, shown in Figs. 7 and 8. A series of wall ironing operations is used to reduce the outer diameter **I** of drawn container **44** to the diameter of the finished container shown in Figs. 7 and 8. Such wall ironing operations are well known in the art and involve forcing the container through one or more rings of narrowing diameter. The ironing ring and the ironing punch further cooperate to reduce the wall thickness of the container to the thickness of the finished container. The reduction in diameter and wall thickness causes the container to increase in length to the appropriate height. The wall ironing operations may be performed using commercially available wall ironing systems equipment such as that available from Frattini S.P.A. (Seriate, Italy), or bodymakers such as those available from Carnaud Metalbox (Shipley, West Yorkshire, England), Ragsdale (Englewood, Co) or Standun (Rancho Dominquez, CA).

[0043] The drawing punch and the first ironing punch (not shown) have the same configuration, with inner diameter **M** and conical taper **K**, as shown by comparison of the drawn and wall ironed containers depicted in Figs. 6 and 7. The first ironing ring (Fig. 7, not shown) has an inner diameter **N**, which is approximately halfway between the outer diameter **I** of drawn container **44** and the outer diameter of the finished container. The resulting first ironed container has a configuration similar to that of drawn container **44**, except that it has a slightly narrower outer diameter **N** and correspondingly increased length **O**.

[0044] The final ironing ring (not shown) has an inner diameter **P** that is identical to the outer diameter of the finished container, as shown by the wall ironed container depicted in Fig. 8. The final ironing punch (not shown) has a similar configuration to the drawing punch, but contains a second conical portion on its outer surface to form a taper **Q** in the wall thickness of

the final ironed container **44**. As best seen in Fig. 9, conical taper **Q** has an angle of approximately 0.5° and defines a transition between a bottom wall portion **48** with thickness **R** and a top wall portion **50** with thickness **S**. The length of conical taper **Q** will vary according to the difference between bottom wall thickness **R** and top wall thickness **S**. In addition to reducing the outside diameter and wall thickness of the container to the diameter and thickness of the finished container, the final ironing step also increases the height of the container to a length **T**, which is appropriate to accommodate the subsequent dome forming and trimming operations.

[0045] In a preferred embodiment conical taper **Q** begins approximately 90 mm from the base of the container. Bottom wall portion **48** is identical to the corresponding portion of drawn container **44**, with interior diameter **M** and conical taper **K**. Wall thicknesses **R** and **S** range from 0.20-0.40 mm, top wall thickness **S** being greater than bottom wall thickness **R** to provide support for subsequent neck forming operations. In an alternative embodiment, the wall may have a uniform thickness without a taper **Q**.

[0046] Those of skill in the art will appreciate that the angle of tapers **K** and **Q** may vary according to size of the container and the metal alloy used to form the slug. In particular, taper **Q** results in a container having a bottom wall portion **48** with a larger interior diameter than the top wall portion **50**. It will be understood by those of skill in the art that, if the angle of taper **Q** is too great and/or the metal alloy is relatively inflexible, then the wall ironed container may lock onto the ironing punch.

[0047] As shown in Fig. 10, the final wall ironed container **52** is inserted into a bottom forming die (not shown) to create a dome **54** with height **U** in the base **56** of the container. Dome **54** provides increased resistance to pressurized contents and ensures that base **56** provides a stable support for the container, as is well known in the art. In a preferred embodiment, height

U of dome **54** is approximately 11.5 mm and reduces the container height **T** by approximately 3 mm, shown by length **V**.

[0048] As shown in Fig. 10, the top of domed container **58** is trimmed by approximately 10-20 mm, as shown by length **W**. This trimming step provides a smooth, even edge for subsequent finishing steps. As described above, the domed, trimmed container may then receive interior and exterior coatings and lithography, and is necked and provided with a closure as is well known in the art.

[0049] In addition to allowing the use of high-strength alloys, the present invention also increases the cold working of the metal by the multiple drawing and wall ironing steps. This additional cold working increases the material strength and complements the use of high-strength alloys to produce thin-walled containers. Furthermore, such cold working also increases the smoothness of the inner and outer surfaces of the finished container, which enhances the appearance of the container and the application of coatings and lithography.

[0050] The Example below is illustrative of the present invention for making thin-walled lightweight metal containers.

<u>Example</u>

[0051] The following example describes the formation of an extruded, wall ironed and bottom formed cylindrical metal container having a diameter of 65.85 mm and a height of 166.0 mm, in accordance with the present invention. A cup **10** is formed by impact extrusion of disk-shaped metal slug **16** having a diameter **E** of 77.50 mm and a thickness **F** of 2.438 mm. The extrusion die **18** is cylindrical, with an interior wall **22** that is 77.85 mm in diameter. The bottom **24** of die **18** has a flat, circular central portion **26** having a diameter of 32 mm, and a conical outer ring **28** with an angle of 1°. The extrusion punch **20** is cylindrical, with an outer surface **30**

that is 77.05 mm in diameter. The transition between outer surface **30** and face **32** of the extrusion punch is a curve **34** with a radius of 6.600 mm.

[0052] Metal slug **16** is placed in extrusion die **18** and struck by the extrusion punch with sufficient force to produce cup **10** having a bottom thickness **B** of 0.600 mm. The resulting cup **10** is cylindrical, with a diameter **A** of 77.85 mm, a wall thickness **C** of 0.400 mm and an average height **D** of approximately 87.88 mm. In addition, the base **12** of cup **10** is conical with a flat, circular central portion **38**, that corresponds to the configuration of the bottom of extrusion die **18** and the face **32** of the extrusion punch **20**. The corner of the cup has an interior radius **G** of 6.600 mm.

[0053] The extruded cup **10** is drawn to the approximate diameter of the finished container, and then bottom formed to remove the conical shape of the base of the cup. The drawing die is cylindrical, with an inner diameter of 66.19 mm. The drawing punch is also cylindrical, with an outer diameter of 65.39 mm, and has a conical segment at the end of the punch, adjacent to the face. The conical segment is 11.88 mm long and tapers from an outer diameter of 65.39 mm to a diameter of 64.99 mm. Thus, the drawing operation reduces the outer diameter **I** of the container from 77.85 mm to 66.19 mm, while maintaining the extruded wall thickness **C** of 0.400 mm. As a result, the average height of the container **J** is increased to approximately 109.78 mm. In addition, the conical segment of the drawing punch forms a taper **K** in the wall thickness adjacent the base of the container from 0.400 mm at the body of the container to 0.600 at the base of the container.

[0054] The drawn container **44** is subsequently inserted into a bottom forming die with a flat bottom, to remove the conical shape of the base **12** of cup **10** and to reduce the corner **46** of the container to its final radius. The face of the drawing punch mirrors the configuration of the

bottom of the bottom forming die. The transition between the outer surface and face of the drawing punch is a curve with a radius of 3.000 mm. Thus, the bottom forming operation reduces the interior radius **L** at the corner of the container from 6.600 mm to its final radius of 3.000 mm.

[0055] The drawn container **44** is wall ironed in stages to reduce the diameter and wall thickness of the container to its final diameter and thickness. The drawn container **44** is passed through a first ironing ring with an inner diameter of 66.07 mm. The configuration and dimension of the corresponding first ironing punch are identical to the drawing punch. Thus, the first wall ironing operation reduces the outer diameter **N** of the drawn container from 66.19 mm to 66.07 mm. In addition, the wall thickness of the container is reduced from 0.400 mm to 0.340 mm, with a taper **K** in the wall thickness adjacent the base of the container from 0.340 mm at the body of the container to 0.540 mm at the base of the container. As a result of the first wall ironing operation, the average height **O** of the container is increased from 109.78 mm to a length of approximately 135.34 mm.

[0056] The container is then passed through a second ironing ring to reduce the diameter and wall thickness of the container to its final diameter and wall thickness. The second ironing ring has an inner diameter of 65.85 mm. In contrast to the previously described punches, the second ironing punch is conically shaped to produce a container with different top and bottom wall thicknesses. The second ironing punch has the same configuration and dimensions as the first ironing punch (and drawing punch), except that it contains a conical segment 5.7 mm long, which begins 90 mm from the face of the ironing punch and tapers from an outer diameter of 65.39 mm to a diameter of 65.29 mm. Thus, the second wall ironing operation reduces the outer diameter of the container **P** from 66.07 mm to its final diameter of 65.850 mm. In addition the

wall thickness of the container is reduced from 0.340 mm to a bottom wall **48** thickness of 0.230 mm and a top wall **50** thickness of 0.280 mm. The taper **K** at the base of the container is also reduced in wall thickness, varying from 0.230 mm at the body of the container to 0.430 mm at the base of the container. As a result of the second wall ironing operation, the average height **T** of the container is increased from 135.34 mm to a length of approximately 180.0 mm.

[0057] The wall ironed container is inserted into a second bottom forming die to form a dome **54** in the base of the container. As the bottom forming die forces the metal at the base of the container upward to form dome, the walls of the container are drawn down toward the base causing a reduction in the height of the container. It has been empirically determined that a dome height of 11.50 mm reduces the height of the container by approximately 3.0 mm. Thus, the dome forming operation produces a container with an average height of approximately 177.0 mm, which is approximately 11 mm longer than the 166 mm finished height of the container. This extra length allows the top of extruded, ironed container **52** to be trimmed to its final length, thereby removing any imperfections at the end of the container and providing a smooth even edge for subsequent finishing steps.

[0058] It will be apparent to those skilled in the art that modifications may be made without departing from the spirit and scope of the invention.